as property of matter. The velocity of sound in crystalline solids remains, however, almost as remote as before, although in this field a fundamental interpretation is at least possible. Any device for measuring this quantity should, therefore, be made known.

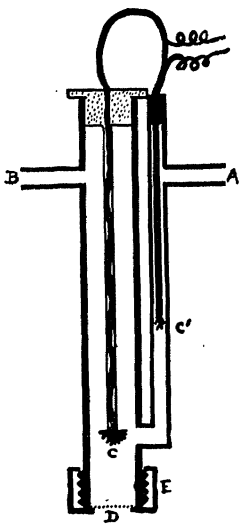

FIG. 1

The accompanying sketch illustrates an apparatus for the purpose which seems capable of development to the necessary precision. A brass tube with entrance A and exit B, through which a gentle stream of thermostated liquid is maintained, is fitted with a multiple-junction thermoelement CC'. The compound junction C is wound with celluloid cement and silk to cause it to absorb sound. A plane-parallel faced sample of the substance under investigation may be inserted at D and secured by the screw-cap E, or at D there may be placed a very thin membrane of cellophane, and the solid under investigation interposed in the path of the impinging sound.

The principle of the apparatus depends upon the work of Boyle and Rawlinson,[1] who have shown that a train of plane sound waves traveling with a velocity v in an infinite homogeneous medium of density ρ will be reflected, when incident normally upon an infinite parallel-faced partition of thickness l and density ρ, according to the relation

$$R = \frac{\left(\frac{v\rho}{v_1\rho_1} - \frac{v_1\rho_1}{v\rho}\right)^2}{4\cot^2 2\pi \frac{l}{\lambda_1} + \left(\frac{v\rho}{v_1\rho_1} + \frac{v_1\rho_1}{v\rho}\right)^2}$$

where v_1 and λ_1 represent the velocity and wave-length of sound in the reflecting medium and R is the ratio of reflected to incident intensity. Boyle and Froman[2] have demonstrated the experimental validity of this expression for ultrasonic waves in media of finite extension. Since this function becomes zero for integral values of $2l/\lambda_1$ it is apparent that the absorption of sound by the thermoelement, and consequently the convergence temperature of thermostated liquid and thermoelement, will vary periodically with the thickness of the interposed solid layer.

The apparatus has been tested roughly in this laboratory, and found capable of operation with sound intensities of less than 0.01 watt per cm.[2] It has the advantage that, apart from the frequency measurement, it needs no more precise apparatus than an ordinary micrometer. Its chief disadvantage is that it requires a plane wave-source.

This note is submitted in the hope that it may catch the eye of some investigator with time and inclination to develop the method. In its present form it can lay claim neither to originality nor to completeness.

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SPECIAL ARTICLES

SEXUAL VARIATIONS IN THE PELVIS[1]

INTERPRETATION AND PRACTICAL SIGNIFICANCE

IN this preliminary report we wish to show that male stigmata in the female pelvis tend to limit pelvic capacity; that the changed architecture resultant on the presence of these features can be appreciated by x-ray examination of the pelvis; that such knowledge is of considerable practical prognostic value to the obstetrician.

Studies in habitus and constitution are tending to isolate characteristic groups which indicate a predisposition to develop certain pathological states. During recent years such workers as Greenhill,[2] Cornell,[3] Davis,[4] De Lee[5] and Solomons[6] have stressed the obstetrical significance of these constitutional abnormalities. Of particular interest to the obstetrician is the so-called masculine type. These women frequently present a masculine physical make-up. They are rather prone to menstrual irregularities, late marriage, sterility, obesity and toxemias of pregnancy. Realizing the importance of the overlap of the sexual characteristics in the female, we have made an investigation on the form of the pelvis and on pelvic capacity

[1] *Trans. Roy. Soc. Can.*, 22: 55, 1928.

[1] From the Department of Obstetrics and Gynecology, Columbia University and the Sloane Hospital for Women, New York City.

[2] J. P. Greenhill, "The Dystrophia Dystocia Syndrome as an Indication for Caesarean Section," *Surg. Clin. N. Amer.*, p. 811, June, 1924.

[2] *Can. Jour. Research*, 1: 405, 1929.

[3] E. L. Cornell, "The Conduct of Labor in the Dystocia Dystrophia Syndrome Patient," *Surg. Gynec. and Obst.*, pp. 707–710, November, 1931.

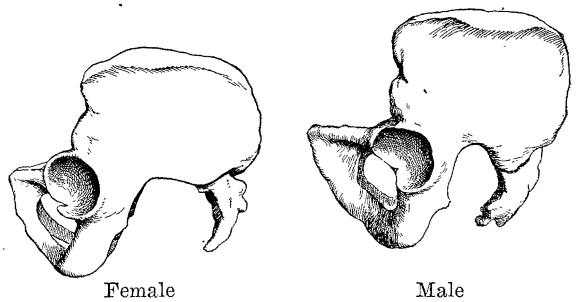
[4] A. B. Davis, "Extra Peritoneal Caesarean Section in Presumably Infected and Mismanaged Cases of Prolonged Labor," *Amer. Jour. Obst. and Gynec.*, Vol. 7, pp. 373–383, April, 1924.

[5] J. B. De Lee, "Principles of Obstetrics," 1928.

[6] Bethel Solomons and Wentworth A. Taylor, "The Diagnosis of Disproportion Antenatal and Intranatal with a View to Treatment," *Jour. Obst. and Gynec.*, Brit. Emp., Vol. 36: 293–324, 1929.

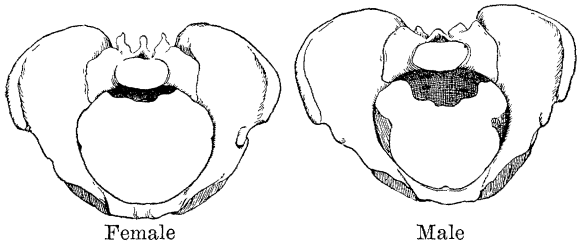
in relation to the ease or difficulty of labor in this type of individual.

The characteristics of the average male and female pelvis are quite well known (Figs. 1 and 2). Anato-



Female Male

FIG. 1. Lateral view of adult female and male pelvis. Note contrast in size and shape of the sacrosciatic notch and relative position of sacrum. In the male note that the ilium forms the upper third of the posterior boundary of the sacrosciatic notch.



Female Male

FIG. 2. View through inlet of adult female and male pelvis. Note the position of the lower lateral border of the sacrum in relation to the ischial spines, in the male pelvis.

mists and anthropologists have studied their characteristic sexual features and have long appreciated their practical importance in sexing unknown skeletal material. Such workers as Thomson,[7] Derry,[8] Hart,[9] Wood Jones and Elliot Smith[10] have carefully described these features and at the same time have stressed the frequency of the overlap of these characters. Straus[11] in 1927 very completely summarized the various opinions and evaluated the several sexual characteristics hitherto discussed. He states, "All of the characters studied, . . . vary so greatly and exhibit such marked sexual and stock-linked overlapping that they are of limited value in sexing . . . pelves."

[7] Arthur Thomson, "Sexual Differences of the Foetal Pelvis," *Jour. Anat. and Physiol.*, Vol. 33, pp. 359–380, 1898–99.

[8] Douglas E. Derry, "Note on the Innominate Bone as a Factor in the Determination of Sex; with Special Reference to the Sulcus Praeauricularis," *Jour. Anat. and Physiol.*, Vol. 43, pp. 266–276, 1908–1909. *Idem*, "On the Sexual and Racial Characters of the Human Ilium," *Jour. Anat.*, Vol. 58, pp. 71–83, 1923.

[9] D. Berry Hart, "On Inversion of the Ilium and Sacrum and Ischium and Pubes (Ilio-Sacral and Ischio-Pubic Bony Segments) as Causes of Deformities of the Female Pelvis," *Edin. Med. Jour.*, Vol. 16, pp. 9–32, 1916.

[10] G. Elliot Smith and F. Wood Jones, "The Archaeological Survey of Nubia," Report for 1907–1908. Vol. 2, 1910.

[11] W. L. Straus, "The Human Ilium; Sex and Stock," *Amer. Jour. Phys. Anthropology*, Vol. 11, p. 1, 1927–28.

LIMITATION OF PELVIC CAPACITY

Due to the kindly cooperation of the curator of the American Museum of Natural History we were permitted to study their valuable collection of pelves. Following careful inspection and study of the dried pelves we were impressed by the sexual variations in the sacrosciatic notch and sub-pubic angles. On viewing a series of pelves, male and female, through the pelvic inlet (Fig. 2) it will be noted that in the former the sacrum towards its lower half is projected forward, encroaching on pelvic capacity. Lateral inspection of the pelves shows the apparent relationship of this feature to variations in size and shape of the sacrosciatic notch. That there may be a definite relationship between a narrow type of sacrosciatic notch and limitation of pelvic capacity as a result of the changed inclination of the sacrum seemed logical.

In order to establish a relationship, if it existed, we examined 70 specimens, 35 sexed as male and 35 as female. Internal measurements were limited to the true pelvis and were taken between similar bony points on each bone. The sacrosciatic notch and subpubic angle were measured in degrees by the camera lucida. Appreciating the personal error in measuring an irregular bony notch, the breadth of the notch at its widest diameter was carefully recorded. This measurement is practically identical with Thomson's[7] distance from the junction of the posterior inferior iliac spine and external margin of the sacrum to the anterior margin of the great sacrosciatic notch. From measurements on eight adult female pelves and five adult male, he noted a characteristic sexual difference in this diameter. For males the average was 40 mm, as contrasted with 49 mm for females. In our series these corresponding measurements averaged for males, 40.8 mm; for females, 53.9 mm. His results and ours thus practically correspond and indicate a definite sexual difference. Curiously enough, both for males and females the right sacrosciatic notch is smaller, but when expressed in averages of the two notches the difference is not great:

Males—right = 40.34	Females—right = 53.31
left = 41.37	left = 54.60

However, in our x-ray series stereographic pictures illustrate very definitely this point. The difference in the notches is slight, of course, but quite apparent. The results, without regard to sex, were submitted to

the Bureau of Statistics at Columbia University and correlations established between the sacrosciatic notch and the internal diameters of the true pelvis. Reference to the accompanying chart shows that the correlations are positive and significant.

TABLE OF CORRELATIONS BETWEEN DIAMETERS MEASURED AND BREADTH AND ANGLE OF SACROSCIATIC NOTCH

No. of pelves	Diameter measured	Breadth of notch	Angle of notch
70	Ant. post of inlet	R = .3885	R = .3594
71	Trans. of inlet	R = .4894	R = .1352
68	Symphysis to tip of sacrum	R = .6808	R = .3799
68	Inter-tuberous	R = .7802	R = .5686
71	Sub-pubic angle	R = .5714	R = .4709
54	Sacrum to spine of ischium	R = .9186	R = .6923
68	Sacrum to tuberosity of ischium	R = .8726	R = .6879

Correlation between angle of notch and breadth of notch: R = .7527.

Average height of true pelvis: Male = 97.6; Female = 86.8.

The breadth of the notch appears to bear a higher relationship than the size of the notch expressed in degrees. This conflicting result can be attributed to the difficulty encountered in picking points from which to use a protractor and so express the true angle of the notch. As one would expect there is a very direct relationship between the diameters from the lateral border of the sacrum to the spine and to the tuberosity of the ischium. This clearly indicates that the inclination of the sacrum is dependent on the terminal portion of the ilium and that when the size and shape of the sacrosciatic notch varies, the sacrum likewise assumes a changed inclination. Both the intertuberous diameter and the sub-pubic angle, as one would expect, show a reasonably high correlation, particularly so when it is realized that one half of the pelves measured were sexed as females with a wide typically female outlet. The antero-posterior diameter and transverse diameter of the brim show a lower but very definite relationship. Generally speaking, the results of the correlations lead us to conclude that, given a narrow sacrosciatic notch, all internal diameters of the true pelvis are decreased, incident to the degree of the correlation. This limitation of pelvic capacity is particularly prone to occur in the portion of the pelvis posterior to the ischial spines. At the present time we are establishing correlations on a series of female pelves and these results will undoubtedly correspond favorably.

PRACTICAL SIGNIFICANCE

In the living woman the sacrosciatic notch is bridged by the sacrospinous and sacro-tuberous ligaments. These ligaments arise from the ischial spine and tuberosity and spread, fanwise to their insertion along the lateral border of the sacrum and to the posterior inferior iliac spine. By rectal palpation the rounded free edge of the sacrospinous ligament can be felt, and with practice the distance between the ischial spine and lateral lower border of the sacrum can be appreciated. When the sacrosciatic notch assumes a narrow male form the sacrum moves forward in the pelvis, decreasing the length of the ligaments. Decrease in the length of the ligaments means, in labor, taut, unresistant tissue. In this event, the labor becomes proportionately more difficult, rotation may fail to occur, and the capacity of the roomy mid-pelvis is encroached upon. Thus, with the sacrum assuming a forward position in the pelvis, rotation of the foetal head becomes more difficult or occipito posterior positions more frequent with fixation of the head and arrest in this unfavorable position.

In our follow-up clinic we have submitted patients who have required operative interference to a roentgenological examination. Lateral x-ray exposures of the pelvis give a fairly accurate appreciation of the relative size and shape of the sacrosciatic notch. We find that in those individuals who had had difficulty in labor a high percentage showed a tendency to a male type of notch. (Fig. 3.)

FIG. 3. Reproduction to scale of x-ray films of masculine type of female pelvis. Medium forceps delivery. Note encroachment of sacrum on pelvic capacity and male type of sacrosciatic notch. The ilium forms part of the upper posterior boundary of the notch.

COMPENSATION

The following observations are based on interpretation of x-ray films from our follow-up clinic. In each case we were aided by a history of the obstetrical difficulty encountered and a knowledge of the form

of the sexual variations gained from a study of the dried pelves mentioned above.

Derry[8] in 1909 suggested that a wide sacrosciatic notch was of greater importance for easy labor than a wide sub-pubic angle. From our x-ray examination of the so-called funnel type this observation can be supported. Spontaneous delivery has occurred in cases of rather marked degrees of narrowing of the sub-pubic angle, but invariably in these cases the sacrosciatic notch was wide, associated with a long terminal ilium. Williams[12] has stressed the importance of the posterior sagittal diameter. This is, of course, an accurate index of the pelvic outlet, but the basic anatomical factor behind a wide or a narrow posterior sagittal diameter is high up in the pelvis, in the form and size of the sacrosciatic notch. The first obstetrical difficulty is then encountered in mid-pelvis. The exception to this rule occurs in an abnormal forward curvature of the lower end of the sacrum such as is met with in rickets. We have noted in several funnel pelves delivered by Caesarean section a wide female type of notch. In view of the possibility of compensation we feel that in the future such cases might be allowed trial labor. On the other hand, with a combination of two male stigmata, such as a narrow sacrosciatic notch and a narrow sub-pubic angle, difficulty at time of labor can be expected. In this type of case elective Caesarean section can be sanely advised, as a reasonable method of delivery. The question of compensation does not appear to be entirely limited to the variations of the sacrosciatic notch and sub-pubic angles. It resolves itself into the appreciation of the fact that the pelvis is a very variable portion of the skeleton, and although in one region it may contain a stigma tending to limit its capacity, in others it is prone to attempt to compensate. Derry[8] has shown that in the male the apex of the sacrosciatic notch is nearer to the auricular surface than in the female. Straus[11] admits this observation but considers it is only true on the average. He states, "Sometimes the notch is 'typically' female when the lower ilium is short (male) and in other instances the notch may be quite male in type when the lower ilium is long." In our x-ray series we have noted these points. Although the shape of the inlet is modified by the shape of the sacrosciatic notch and terminal ilium, usually the anterior portion of the pelvis compensates favorably. In one case the forward movement of the auricular surface toward the apex of the notch gave a decided heart-shaped appearance to the inlet with inward curvature of the ilio-pectineal line and projection forward of the sacral promontory. This resulted in the longest transverse diameter of the inlet being situated nearer the sacral promontory than is commonly found in the typical female pelvis.

[12] J. W. Williams, "Obstetrics." Sixth Edition, 1930.

The Deep Pelvis

From measurements based on 35 male and 35 female pelves we find a significant sexual difference in the depth of the true pelvis. The pelvic depth was taken as being the greatest perpendicular distance from the tuberosity of the ischium to the ilio-pectineal line. In males this averaged 97.6 mm, in females 86.8 mm. Thomson[7] cites Verneau's measurements: for males 107 mm; for females 93 mm. In our x-ray series we find rather frequently women with thick masculine type of bones and increased depth to the true pelvis. An increase of 1 cm in the depth of the pelvis presupposes increased length of the pubic rami. In such a case the outlet or intertuberous diameter may be proportionately increased, the inherent size of the sub-pubic angle not necessarily being affected. In the event of an associated narrowing of the sub-pubic angle with increased length of the pubic rami, the outlet may present normal dimensions. This normal intertuberous measurement may thus obscure a dangerous type of funnel pelvis.

Conclusions

We feel that the size and shape of the sacrosciatic notch give an index of pelvic capacity and that variations therein may be indicative of male stigmata. X-ray examination of the pelvis gives an appreciation of these variations and also additional information concerning the form of the sub-pubic angle and a general conception of the bony architecture which may be of prognostic importance.

Detailed results of this investigation will be published later.

W. E. Caldwell
H. C. Moloy

BOOKS RECEIVED

Bent, Arthur. *Life Histories of North American Gallinaceous Birds.* Pp. xi + 490. 93 plates. U. S. National Museum, Bulletin 162. Smithsonian Institution. U. S. Government Printing Office. $1.00.

Densmore, Frances. *Menominee Music.* Pp. xxii + 230. Illustrated. Bureau of American Ethnology, Smithsonian Institution. U. S. Government Printing Office. $.80.

Freudenberg, K. *Stereochemie.* Pp. 161–320. Illustrated. Franz Deuticke, Leipzig.

Griscom, Ludlow. *The Distribution of Bird-Life in Guatemala.* Pp. ix + 439. 11 figures. American Museum of Natural History.

Hellmayr, Charles E. *The Birds of Chile.* Volume XIX, Pp. 472. Field Museum of Natural History. $2.50.

Kellogg, Remington. *Mexican Tailless Amphibians in the United States National Museum.* Pp. iv + 224. 24 figures. Smithsonian Institution, U. S. Government Printing Office.

Sutton, George M. *The Birds of Southampton Island.* Pp. 275. 24 plates. Carnegie Institution.